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# United States Patent [19]

Richardson

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[54] SELECTABLE MECHANICAL AND ELECTRONIC PATTERN GENERATING APERTURE MODULE

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[*] Notice: The portion of the term of this patent subsequent to Jan. 2, 2007 has been disclaimed.

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[51] Int. Cl.[5] ..... F21V 11/00

[52] U.S. Cl. ..... 362/282; 362/324; 362/284

[58] Field of Search ..... 350/331 R; 353/122, 353/110; 362/268, 276, 280, 284, 323, 324

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| | | |
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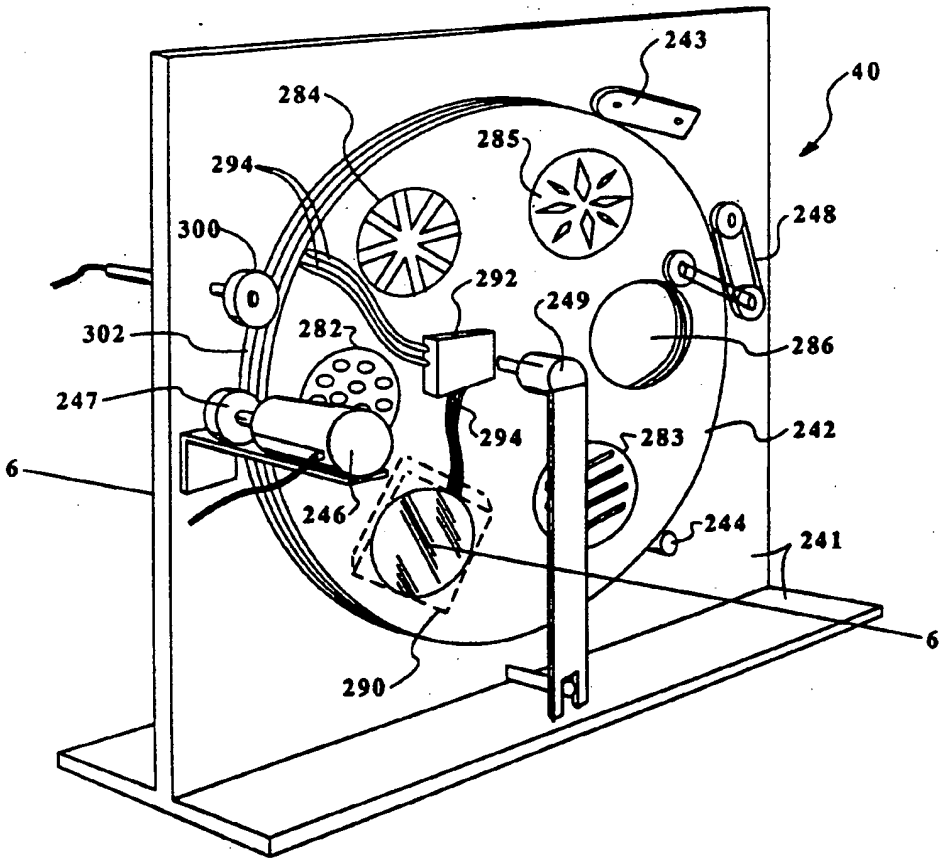
[57] ABSTRACT

A lighting system aperture mechanism formed by a movable carriage including a frame with openings for mechanically formed or electronic pattern apertures. The frame is moved to position a selected opening around a beam of light and the pattern aperture disposed within the selected opening may be rotated as desired to produce special effect patterns in the beam of light.

23 Claims, 4 Drawing Sheets



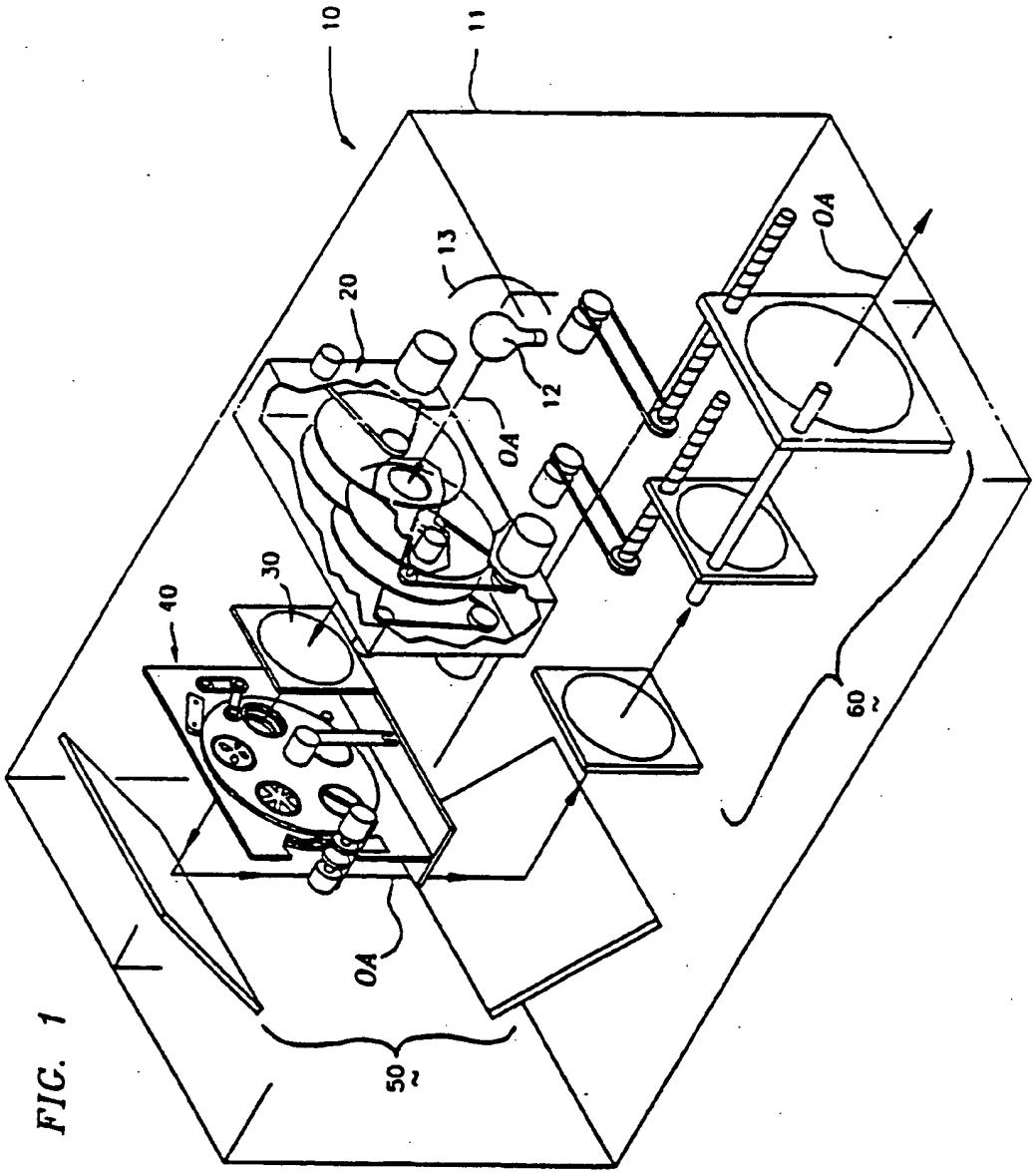



FIG. 1

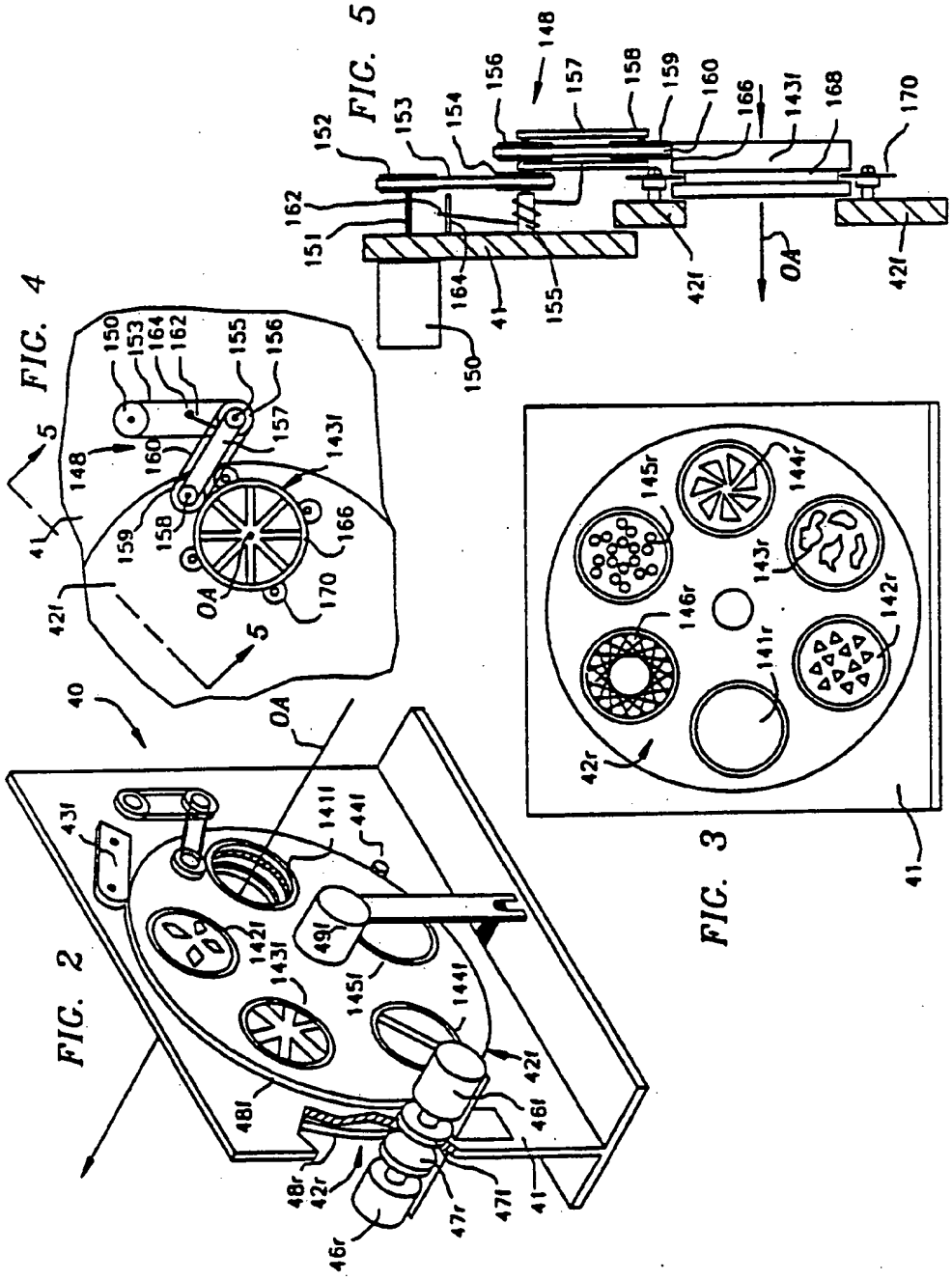


FIG. 5
FIG. 4
FIG. 3
FIG. 2
OA
5
40
41
42r
42l
43l
46r
46l
47r
47l
48r
48l
49l
141r
141l
142r
142l
143r
143l
144r
144l
145r
145l
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156
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160
162
164
166
168
170

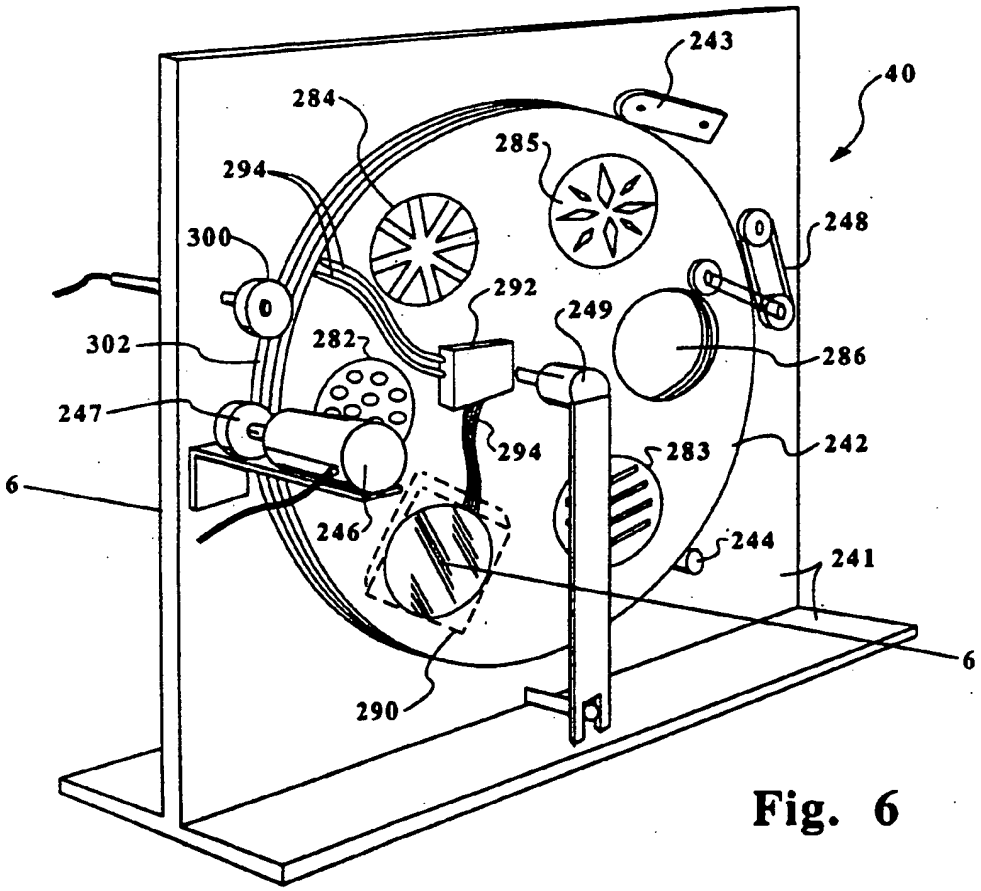
243
40
284
285
294
248
300
292
249
302
282
286
247
294
283
242
6
246
244
241
6
290

Fig. 6

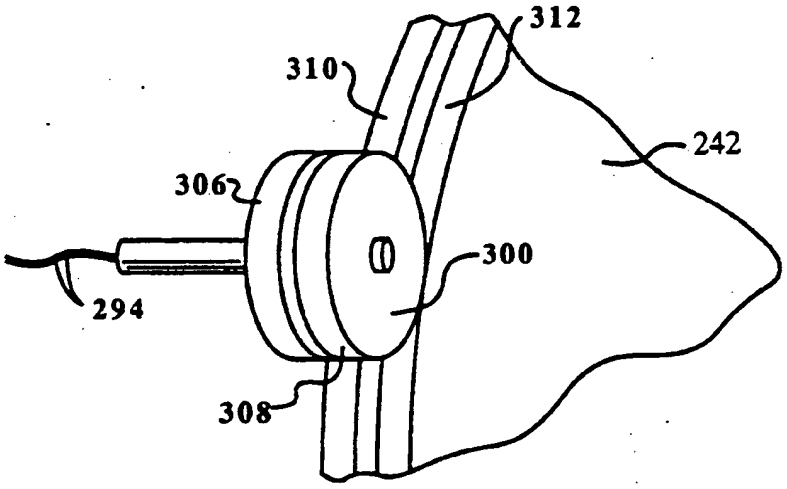
312
310
242
306
300
294
308

Fig. 7

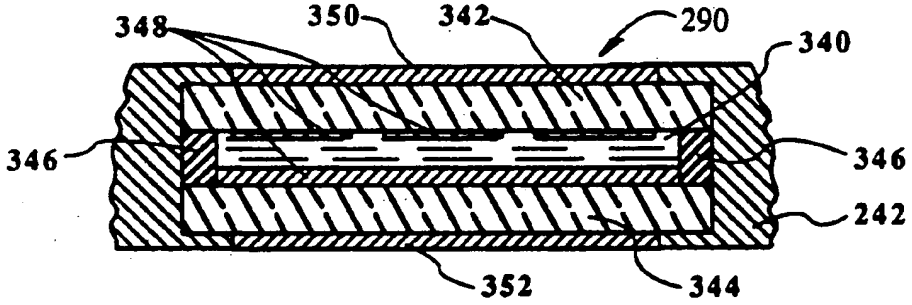
348
350
342
290
340
346
346
242
352
344

Fig. 8

# SELECTABLE MECHANICAL AND ELECTRONIC PATTERN GENERATING APERTURE MODULE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to optical aperture mechanisms and more particularly to a mechanism including multiple selectable and rotatable pattern apertures or transparent liquid crystal displays.

This application is related to copending application Ser. No. 07/224,438 filed Jul. 26, 1988, now U.S. Pat. No. 4,891,738, issued Jan. 2, 1990, entitled "Selectable Aperture Module", assigned to the assignee of the present invention.

2. Discussion of the Prior Art

Conventional theatrical and display lighting systems have used various types of optical filters which are removably insertable into light beams to modify the distribution of light in the projected beam. U.S. Pat. No. 2,214,728 describes a color wheel which includes several optical filters and which is rotatable to position a selected filter across a beam of light. The several filters have equal areas with uniformly dense coloring and do not produce different shapes in the projected beam of light.

U.S. Pat. No. 1,449,122 describes a kaleidoscope projector including several hollow tubes that are lined with different numbers of mirrors and supported in a frame which is rotatable to position a selected tube around light in a beam along an optical axis. Tube rotation gears are used to turn the selected tube of mirrors to spin the kaleidoscopic beam around the optical axis. However, the rotatable mirror tubes cannot stencil patterns into the beam, which requires a pattern aperture in a focal plane of the projector. The beam of light may be conventionally patterned by a strip of film scrolled across the beam between opposite side spools.

U.S. Pat. No. 3,030,856 describes a kaleidoscope projector which forms variable apertures using a pair of main disks each supporting a plurality of smaller disks around its periphery. Each smaller disk has translucent apertures spaced regularly around its own periphery. The main disks and each of the smaller disks are simultaneously rotated to continuously, and practically uncontrollably, vary the effective aperture shape and the pattern of light in the beam projected from the kaleidoscope.

U.S. Pat. No. 4,232,359 describes an illumination system including a plurality of shutters having edges or patterns of desired shapes, one or more of which may be manually inserted into, and remain fixed at a respective location in, a beam of light.

U.S. Pat. No 4,460,943 describes a light projector including a disc which has a number of openings for mounting "gobos" (stencils for light) and which is rotatable to insert a selected gobo into the focal plane of a beam of light.

Liquid crystal displays (LCD) have been used in a wide variety of different projection and display applications. U.S. Pat. Nos. 4,195,915 and 4,443,819 describe using a reflective type LCD to project television images. U.S. Pat. Nos. 4,222,641, 4,294,524 and 4,368,963 describe a projector system which projects light through a stationary transparent LCD onto a cinema screen. U.S. Pat. Nos. 3,722,988, 3,844,650, 3,895,866, 4,671,634, 4,722,593, 4,756,604 and 4,345,258 all describe various types of transparent LCD projectors where the LCD is fixed in a stationary position.

U.S. Pat. No. 4,568,080 describes a transparent LCD display in which the LCD may be placed in a number of different operative positions. However, once the LCD is affixed in a particular position it may not thereafter be moved to a different position without dismantling the display system. Hence, none of the above prior art teaches or suggests automatically positioning the LCD in front of a light beam or selectively interchanging that LCD with a number of mechanically formed apertures so as to controllably vary the projected pattern of light.

U.S. Pat. Nos. 4,693,557 and 4,613,207 describe a motion picture projector in which a continuous strip of transparent liquid crystal material capable of temporarily storing charge is utilized to create a series of picture frames for projection onto a screen. As each frame is created and projected, it is moved out of the way and the next frame is moved into the projection optics for projection. Images are created on the liquid crystal material by passing the liquid crystal material beneath a dynamic electrode, formed in the shape of a roller, which charges selective portions of the LCD so as to form the desired images. In both of these patents, no provision is made to project light onto the screen in any other manner than through the liquid crystal material.

## SUMMARY OF THE PRESENT INVENTION

It is therefore a primary objective of the present invention to provide an aperture apparatus including multiple pattern aperture means which are selectively and automatically positionable and rotatable around an optical axis.

Another objective is to provide a unitary and flexibly operable aperture apparatus for performing functions previously requiring separate aperture apparatuses.

A further objective is to provide an aperture apparatus including means for selectively and automatically positioning a transparent LCD within a projection light beam.

Briefly, a preferred embodiment of the invention is formed from base means, carriage means including frame means which has multiple openings and which is movably supported on said base means, multiple pattern aperture means formed by aperture plates and aperture holders rotatably engaged adjacent respective ones of said openings, frame drive means for selectively moving said frame means to center a selected opening around an optical axis, and aperture drive means for spinning a certain selected pattern aperture means centered on the optical axis. Alternatively, one or more of the pattern aperture means may be replaced by a nonrotatable electronic aperture means capable of creating an unlimited variety of patterns.

The present invention has the advantage that certain selected pattern aperture means can be spun, in a desired direction at a desired speed, to produce special effect patterns in a beam of light projected therethrough.

These and other objects of the present invention will become apparent to those skilled in the art upon reading the following detailed description of the preferred embodiment as shown in the accompanying drawing figures.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an isometric view of a lighting system including a preferred embodiment of a selectable aperture module according to the present invention;

FIG. 2 is an isometric view of the selectable aperture module of FIG. 1;

FIG. 3 is a rear elevational view of a FIG. 2 frame wheel engaging example pattern aperture means;

FIG. 4 is a front elevational view of the FIG. 2 aperture drive mechanism;

FIG. 5 is a cross-sectional view taken along line 5—5 through the FIG. 4 aperture drive mechanism and, for the sake of clarity, omitting the rear frame wheel;

FIG. 6 is an isometric view of an alternative embodiment of the selectable aperture module of FIG. 1 incorporating an electronic aperture means;

FIG. 7 is a partially-broken perspective view of the electrical connectivity means of the alternative embodiment of the aperture module of FIG. 6; and

FIG. 8 is a partially-broken cross-sectional view taken along the line 6—6 through the electronic aperture means of FIG. 6.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is preferably embodied in a selectable aperture module **40** which may be used in the context of a spot light projection system **10** as illustrated in FIG. **1**. System **10** is mounted within a (schematically outlined) housing **11** and includes a light source such as a short arc lamp **12** with a parabolic reflector **13** which radiates light around optical axis OA (leftward in FIG. **1**). The radiated light is conventionally filtered through a "hot filter" (not shown) which removes infra-red and ultra-violet light while passing visible light. The visible light in a beam is preferably passed through a spectral filtering module **20** which controls its color and intensity as disclosed in Applicant's co-pending application Ser. No. 224,436 filed Jul. 26, 1988, now U.S. Pat. No. 4,914,556, issued Apr. 3, 1990.

Downstream from filtering module **20**, the filtered light beam is preferably diffused through an acid-etched glass plate diffusor (not shown). The optionally filtered and diffused light beam is then passed through a condenser lens **30** which focuses the beam downstream towards selectable aperture module **40**.

Aperture module **40** holds multiple apertures in one or more planes normal to axis OA at or near a focal point of lens system **60**. A selected aperture is positioned to be intersected by the beam of light as described below.

Between various elements of system **10** the light beam may be reflected by one or more mirrors in a beam folding means **50** to minimize the size of the housing **11**. Downstream from aperture module **40** the patterned beam of light traverses zoom lens system **60**, whereby the beam is focused and projected from system **10** as further described in Applicant's co-pending application Ser. No. 224,437 filed Jul. 26, 1988, now U.S. Pat. No. 5,029,992, issued Jul. 9, 1991. The beam axis may be directed as desired by vertically tilting and/or horizontally panning housing **11**.

Referring to FIG. **2**, selectable aperture module **40** includes a base panel **41**, carriage means including a first or front frame or carousel wheel **42F** and preferably a second or rear frame or carousel wheel **42R**. Spring-loaded guide rollers (**43F**) in the front and (not shown) in the rear urge frame wheels **42F** and **42R** against fixed guide rollers (**44F**) in the front and (not shown) in the rear. Frame drive motors **46F** and **46R**, which may be analog DC servo motors or digital AC stepper motors, turn drive rollers **47F** and **47R** whose friction against rims **48F** and **48R** turns wheels **42F** and **42R**. Analog servo motor operations cause wheel movements which are preferably sensed by axially-connected potentiometers (**49F**) in the front and (not shown) in the rear.

Front wheel **42F** has, equally spaced in five sectors, one circular opening **141F** which is left empty for entirely passing a beam of light and four circular openings which are used to engage aperture holders of aperture means **142F** through **145F** including pattern aperture plates for patterning the beam of light.

Referring to FIG. **3**, rear wheel **42R** has, equally spaced in six sectors, one circular opening **141R** which is left empty and five circular openings which are used to engage aperture holders of aperture means **142R** through **146R**.

FIGS. **4** and **5** show front wheel **42F** in a different rotational position where pattern aperture means **143F** is intersected by light in a beam around axis OA. Frame wheel **42F** is provided with a holder drive mechanism **148** comprising a motor **150** with a shaft **151** attached to a pulley **152** which engages a belt **153** looped around a pulley **154**. A fixed sleeve **155** has a hollow core containing bearings supporting a rotatable shaft which is attached between pulley **154** and a pulley **156**. Sleeve **155** is pivotally connected to one end of a rigid link **157** which has its other end pivotally connected to a sleeve **158**, similarly containing bearings and a rotatable shaft which is in turn attached to a pulley **159**. Pulleys **156** and **159** are encircled by a belt **160**. A spring **162** is disposed around sleeve **155** with one end compressed against a stop peg **164** and the other end compressed against link **157**. Spring **162** acts through link **157**, sleeve **158** and pulley **159** to force belt **160** against rim **166** of holder **143F**. Aperture holder rim **166**, for example, has a groove **168** guided by washers on pins **170**.

In operation, frame drive motors **46F** and/or **46R** are selectively operated in either direction at selected speed(s) to move frames **42F** and/or **42R** to desired positions. Analog DC servo-motors are preferably controlled by analog or appropriately converted digital signals fed back from potentiometers or encoders **49**. Drive motor **46** operations may optionally be further controlled by a programmed microprocessor (not shown).

When frame wheels **42R** and/or **42F** are positioned with selected aperture means (**143F** for example) centered on optical axis OA the selected front aperture holder may be spun by holder drive mechanism **148**. Motor **150** is selectively operated in either direction at a selected speed to turn belt **160** against rim **166** of the aperture holder and spin the pattern aperture plate intersected by the beam of light around axis OA.

FIG. **6** illustrates an alternative embodiment of the selectable aperture module **40** of FIG. **1**, having a variable electronic aperture means incorporated into the carousel or frame wheel. Selectable aperture module **40** includes a base panel **241**, a carriage means including at least a first or front frame or carousel wheel **242** and preferably a second or rear frame or carousel wheel (not shown in FIG. **6**, but shown in FIG. **2**). A spring-loaded guide roller **243** urges the frame wheels **242** against the fixed guide rollers **244**. A frame drive motor **246**, such as an analog DC servo motor or a digital AC

stepper motor, turns drive rollers **247**, whose friction against rim **302** turns wheel **242**. If a servo motor is used to drive the frame wheel **242**, its rotational movement is preferably sensed by axially-connected potentiometer **249** in order to provide feedback control.

Frame wheel **242** has, equally spaced in six sectors, six circular openings which may be used to engage aperture holders of aperture means **282** through **286** or left empty as a circular opening **281** for entirely passing a beam of light therethrough, as discussed above in the preferred embodiment of the present invention. Alternatively, one or more of the circular openings could be used to form an optically restricting frame around a portion of an electronic aperture means **290**, such as a transparent type LCD or similar type of device. It should be noted that holder drive mechanism **248** would not be utilized when a non-rotatable electronic aperture means is positioned within one of the circular openings.

When an LCD is placed within one of the circular openings of the frame wheel **242**, depending on the type of LCD and how it is connected, an LCD driver and multiplexer circuit **292** may be required to receive certain electrical signals over wires **294**, separate those electrical signals from one another, and then transfer those electrical signals over tape or ribbon connector **294** to LCD **290**.

In the illustrated example of FIG. **6**, frame wheel **242** is designed to be freely rotatable within base panel **241**. Hence, it is essential that frame wheel **242** not be connected to any nonrotatable mechanical or electrical components which would impede its ability to freely rotate. Accordingly, electrical connectivity means **300** is comprised of an electrically coupled roller having two conductor lines which maintain constant contact with two mating conductor lines on rim **302**. Since all of the electrical signals input to driver circuit **292** are sequential in time, the driver circuit **292** must also have multiplexing capabilities so that it may separate these sequential signals and apply them to the LCD **290** over cable **296**.

The interaction between electrical connectivity means **300** and rim **302** is illustrated in FIG. **7**. A main processing system (not shown) determines what charges need to be applied to the LCD **290** in order to create a desired pattern through which light will be projected. The processing system then multiplexes these signals and outputs them over wires **294** to electrical connectivity means **300**. First conductor band **306** and second conductor band **308** are respectively connected to one of the wires **294** and are wound around the roller of electrical conductor means **300**. As the roller **300** moves with the movement of rim **302**, conductor bands **306** and **308** remain in contact with matching first and second conductors **310** and **312** respectively, thereby maintaining a constant electrical connection between the processing system and LCD driver **292**.

It should also be noted that since the amount of power required to run LCD driver **292** and LCD **290** is low, many other types of connectivity means, such as optical links or brush connectors, could be utilized in place of the means shown to achieve the same purpose.

FIG. **8** illustrates a cross-sectional view taken along line **6—6** through the electronic aperture means **290** of FIG. **6**. The type of electronic aperture illustrated is a twisted nematic mode (TN) LCD. Other types of LCD which can be utilized in place of the TN mode LCD include the dynamic scattering mode, guest host mode, and phase shift mode. LCD's are basically electronic shutters, in that they are transparent when no voltage is applied and opaque when voltage is applied.

LCD **290** is formed from a layer of liquid crystal molecules **340** sealed between two glass substrates, front glass substrate **342** and rear glass substrate **344**. Prior to being layered together, electrodes **348** are affixed to the liquid crystal side of the two substrates so that electrical charges are directly applied to the liquid crystals. For instance, a ground electrode is affixed to rear glass substrate **344** and a number of positive charge electrodes **348** are affixed to front glass substrate **342**, so that electrical charges can be separately applied to various different areas on the LCD. A seal **346** is used to retain the liquid crystals within the substrate layers.

The substrate layers are then sandwiched between a front polarizer **350** and a rear polarizer **352** and placed within an opening of frame wheel **242**. It should be noted that LCD **290** has only been shown in a rectangular configuration which is actually imbedded in frame wheel **242** for illustrative purposes. LCD **290** could have just as easily been produced in a rounded configuration which could be readily inserted and removed from the opening in frame wheel **242**.

When no voltage is applied to the electrodes **348**, the liquid crystal molecules align themselves at a 90 degree angle to the axis of the light beam so as to rotate the plane of polarization of the light by 90 degrees, thereby allowing light to pass through both polarizers **350** and **352**. When a voltage is applied to an electrode, the molecules of the liquid crystal material coming directly between the charged electrode and the ground electrode are realigned perpendicular to the substrate, so that the portion of the light beam impinging upon that area of the LCD is cut off by one of the polarizers. To form a desired image, separate charges are applied to different points throughout the LCD so as to only selectively block light from passing through some areas.

Use of an LCD in the present invention allows an operator to create an unlimited number of different patterns through which a bean of light may be passed. In contrast, metal etched apertures, such as aperture means **282** through **285**, limit the quantity of patterns which can be created without disassembling the projection system **10**. Although it would seem desirable to replace all of the metal etched apertures with electronic apertures, such as LCD **290**, presently available LCD's, however, utilize polarization filters which reduce the intensity of light passing through the aperture by up to 50% and have a tendency to create visual distortions when exposed to high intensity light sources over an extended period of time. Thus, it is essential to the present invention that the electronic aperture means be used in combination with other pattern apertures or openings, such that no one electronic aperture is overly exposed to a high intensity light source and such that higher intensity light sources may be utilized.

Although the present invention has been described in a preferred embodiment, it will be appreciated by those skilled in the art that this embodiment may be modified without departing from the essence of the invention. For example the carriage means may include a straight frame which is linearly slidable across the axis of a beam, or a paddle-wheel type frame which is rotatable to position a selected paddle with an aperture holder across the axis of a beam. It is therefore intended that the following claims be interpreted as covering any

modifications falling within the true scope and spirit of the invention.

I claim:

1. A selectable aperture apparatus for use in a stage lighting system or the like, comprising:

base means;

means for movably supporting said base means and having formed therein a first opening and a second opening;

an electronic pattern aperture means disposed within said first opening in said supporting means for selectively forming a plurality of opaque patterns for modifying a beam of light travelling along an optical axis passed through said electronic pattern aperture means, said second opening being capable of allowing the transmission of a beam of light at substantially full intensity, with no significant attenuation therein; and

drive means for controllably moving said supporting means in such a manner so that said first and second openings are selectively intersected by said optical axis.

2. A selectable aperture apparatus as recited in claim 1 and further comprising means for remotely controlling the formation of said opaque patterns by said electronic pattern aperture means.

3. A selectable aperture apparatus as recited in claim 2 wherein said remote controlling means wirelessly communicates with said electronic pattern aperture means to selectively control formation of said opaque patterns.

4. A selectable aperture apparatus as recited in claim 3 wherein said remote controlling means is in hard-wire communication with said electronic pattern aperture means to selectively control formation of said opaque patterns.

5. A selectable aperture apparatus as recited in claim 2 wherein said remote controlling means includes:

means for remotely creating electrical signals corresponding to electrical charges necessary to form said opaque patterns;

electrical driver means for receiving said electrical signals and inputing said electrical signals to said electronic pattern aperture means; and

communicating means for movably hard-wire connecting said remote creating means and said electrical driver means.

6. A selectable aperture apparatus as recited in claim 5 wherein said supporting means comprises carousel wheel means rotatably supported on said base means and wherein said communicating means includes:

first conductor means affixed to said carousel wheel for receiving said electrical signals and communicating said electrical signals to said electrical driver means; and

second conductor means for receiving said electrical signals from said remote creating means and for movably engaging said first conductor means to maintain a constant electrical contact between said first and second conductor means through which said electrical signals may pass.

7. A selectable aperture apparatus as recited in claim 1 wherein said supporting means comprises carousel wheel means rotatably supported on said base means.

8. A selectable aperture apparatus as recited in claim 7, wherein said supporting means has a plurality of additional openings formed therein, and further comprising a plurality of mechanically formed pattern aperture means each coaxially disposed adjacent and rotatably relative to a respective one of said additional openings in said supporting means.

9. A selectable aperture apparatus as recited in claim 8 wherein said second opening in said supporting means is left open so as to freely let said beam of light pass therethrough.

10. A selectable aperture apparatus as recited in claim 1 wherein said supporting means comprises two coaxially supported supporting means independently positionable with respect to one another, wherein each of said supporting means has a first opening and a second opening, and wherein at least one of said supporting means has one of said electronic aperture means disposed within said first opening therein.

11. A selectable aperture apparatus as recited in claim 10, wherein each of said supporting means has a plurality of additional openings formed therein, and each said supporting means further comprises a plurality of mechanically formed pattern aperture means each coaxially disposed adjacent and rotatably relative to a respective one of said additional openings in said supporting means.

12. A selectable aperture apparatus as recited in claim 11 wherein said second opening in each of said supporting means is left open so as to freely let said beam of light pass therethrough.

13. A selectable aperture apparatus as recited in claim 1 wherein said electronic pattern aperture means is a liquid crystal display device.

14. A selectable aperture apparatus as recited in claim 13, wherein said electronic pattern aperture means is a twisted nematic type liquid crystal device.

15. A selectable aperture apparatus as recited in claim 13, wherein said electronic pattern aperture means is a dynamic scattering type liquid crystal device.

16. A selectable aperture apparatus as recited in claim 1 wherein said drive means comprises analog servo motor means and potentiometer means which sense operations of said motor means and in response thereto provide signals for feedback control of said motor means.

17. Apparatus as in claim 1 wherein said drive means comprises digital stepper motor means.

18. Apparatus as in claim 17 wherein said drive means further comprises encoder means which sense operations of said motor means and in response thereto provide digital signals for feedback control of said motor means.

19. A selectable aperture apparatus as recited in claim 1 wherein said supporting means has a plurality of additional openings formed therein, and further comprising a plurality of mechanically formed pattern aperture means each coaxially disposed adjacent and rotatably relative to a respective one of said additional openings in said supporting means.

20. A selectable aperture apparatus as recited in claim 19 and further comprising aperture drive means for controllably rotating one of said mechanically formed pattern aperture means intersected by said optical axis to further modify said beam of light.

21. A selectable aperture apparatus as recited in claim 20 wherein said aperture drive means comprises motor means supported by said base means so as to apply frictional drive forces to one of said mechanically formed pattern aperture means centered on said optical axis.

22. A selectable aperture apparatus as recited in claim 1 wherein said electronic pattern aperture means is coaxially disposed adjacent and rotatably relative to said first opening in said supporting means.

23. A selectable aperture apparatus as recited in claim 22 an further comprising aperture drive means for controllably rotating said electronic pattern aperture means when centered on said optical axis.

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